

VU Research Portal

The Forensic Confirmation Bias

van den Eeden, Claire A.J.; de Poot, Christianne J.; van Koppen, Peter J.

published in

Journal of Forensic Sciences
2019

DOI (link to publisher)

[10.1111/1556-4029.13817](https://doi.org/10.1111/1556-4029.13817)

document version

Publisher's PDF, also known as Version of record

document license

Article 25fa Dutch Copyright Act

[Link to publication in VU Research Portal](#)

citation for published version (APA)

van den Eeden, C. A. J., de Poot, C. J., & van Koppen, P. J. (2019). The Forensic Confirmation Bias: A Comparison Between Experts and Novices. *Journal of Forensic Sciences*, 64(1), 120-126.
<https://doi.org/10.1111/1556-4029.13817>

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal ?

Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

E-mail address:

vuresearchportal.ub@vu.nl

2,750+ DRUG STANDARDS

COVERING A WIDE RANGE OF DRUG CLASSES

MEETING TRADITIONAL AND EMERGING THREATS

Cayman Chemical is a licensed and accredited provider of analytical reference standards for drugs of abuse, NPS, and therapeutic drugs. Our range of analytical standards includes Cocaine & Tropanes, Amphetamines, Benzodiazepines, Barbiturates, Antidepressants, Cannabinoids, and Opioids, among others.

SEARCH OUR ANALYTICAL STANDARDS AT
WWW.CAYMANCHEM.COM/FORENSICS



BIOMEDICAL RESEARCH
PRODUCTS

CONTRACT
SERVICES

ANALYTICAL
STANDARDS

ACTIVE PHARMACEUTICAL
INGREDIENTS

PAPER

GENERAL

Claire A. J. van den Eeden,^{1,2} M.Sc.; Christianne J. de Poot,^{1,2,3} Ph.D.; and Peter J. van Koppen,² Ph.D.

The Forensic Confirmation Bias: A Comparison Between Experts and Novices

ABSTRACT: A large body of research has described the influence of context information on forensic decision-making. In this study, we examined the effect of context information on the search for and selection of traces by students ($N = 36$) and crime scene investigators ($N = 58$). Participants investigated an ambiguous mock crime scene and received prior information indicating suicide, a violent death or no information. Participants described their impression of the scene and wrote down which traces they wanted to secure. Results showed that context information impacted first impression of the scene and crime scene behavior, namely number of traces secured. Participants in the murder condition secured most traces. Furthermore, the students secured more crime-related traces. Students were more confident in their first impression. This study does not indicate that experts outperform novices. We therefore argue for proper training on cognitive processes as an integral part of all forensic education.

KEYWORDS: forensic science, crime scene investigation, expectancy effects, contextual bias, decision-making, expertise

It is impossible to secure every item and trace at a crime scene. Therefore, crime scene investigators have to make decisions about the relevance of the available physical evidence on the spot. These decisions can be based both on the impression of the crime scene itself and on contextual information that is provided, such as investigative leads or witness statements. Hence, contextual information is likely to influence behavior of investigators at the crime scene. The influence of expectancy effects and contextual bias on decision-making has been described in a broad range of forensic disciplines, see (1), for an overview.

In recent years, there has been increased attention for cognitive bias in the forensic science community worldwide (2–4). Also, an increasing body of research focuses on the influence of bias on forensic comparisons in laboratories (5–7). Despite the efforts of various forensic sciences institutes and governments to create awareness of bias, a recent study (8) demonstrates that forensic experts consider bias as something that mainly concerns others, not themselves. Therefore, more research on the influence of the forensic confirmation bias is on the field of practice is necessary. In a previous study, we explored the influence of contextual information on the interpretation of a crime scene. Results demonstrated that experienced crime scene investigators can also be prone to bias and that prior information can help

with the interpretation of the scene when it is correct, but can cause the crime scene to be interpreted wrongfully when it is incorrect (9).

Expertise

Crime scene investigation is a highly specialized domain, and it is generally considered that the more years of experience in the field a crime scene investigator has, the more of an expert he or she is. Ericsson (10) defines expertise as a characteristic that is linked to knowledge, skills, and techniques, distinguishing experts from novices within a particular discipline. A range of studies has shown that experts and novices think and solve problems in different ways. Sometimes it means that experts outperform novices, but sometimes they do not (see [11] for an overview). Experts outperform novices in domains such as generating the best solution to a problem (12), detection and recognition of patterns (13,14) and choosing appropriate strategies for problem solving (15). Also, experts can retrieve domain relevant knowledge with minimal cognitive effort (16). World knowledge and information from previous experiences can be used to interpret new situations. The schemas that experts have can effectively guide attention to areas or aspects that are thought to be relevant based on previous experiences (17). On the other hand, what is perceived may be incorrectly interpreted in a way consistent with the pre-existing schema (18).

There are also other ways in which experts fall short compared to novices. For instance, expertise is domain limited and within their domain of expertise, experts rely on contextual cues and base-rate information that can help to develop hypotheses about what has happened. That can also bias their decisions as it may make them less open-minded toward alternative, less likely, scenarios (19,20). Experts can be overly

¹Research, Knowledge & Development Department, Police Academy of the Netherlands, Apeldoorn, The Netherlands.

²Criminal Law and Criminology Department, VU University Amsterdam, Amsterdam, The Netherlands.

³Amsterdam University of Applied Sciences, Amsterdam, The Netherlands.

Corresponding author: Claire A. J. van den Eeden, M.Sc., Politieacademie, Research, Knowledge and Development, P.O. Box 834, 7301 BB Apeldoorn, The Netherlands. E-mail: claire.van.den.eeden@politieacademie.nl

Received 29 Nov. 2017; and in revised form 23 Jan. 2018, 29 Mar. 2018; accepted 23 Apr. 2018.

confident in their skills (21), and although experts outperform novices in understanding the deep structure of a problem, they sometimes overlook details (22).

Forensic Experts

One of the core aspects of the expertise of the crime scene investigator lies in the ability to recognize places that could contain physical evidence (23). The more experienced a crime scene investigator is, the more schemas he or she has to draw on. That in turn may impact the way a crime scene is assessed and may increase the chances of finding traces (18,24). Previous studies have demonstrated that forensic experts make sense of evidence by reconstructing the actions that may have led to the image produced. As a consequence, experts tend to recover more forensic evidence (25). Baber and Butler (26) conducted an experiment on search strategies of expert and novice crime scene investigators in simulated burglary crime scenes. They found that experts and novices perceive a crime scene slightly different. Both experts and novices reconstructed events by the *modus operandi* of the criminal to make sense of the scene. Novices, however, explored the scene in terms of the individual objects that were present in the crime scene, whereas experts considered objects with “evidential value.” The evidential value is the evidence analysis that could be performed as a consequence of the examination, thus keeping the bigger picture of the criminal investigation in mind.

Dror (27) proposed the hierarchy of expert performance (HEP) framework as an overall single framework that coherently explicates the different aspects of human expert performance, including forensic experts. The framework consists of two main components: biasability and reliability. It is argued that an important component of expert performance across domains relates to biasability. Biasability is explained as the ability to make decisions based on relevant information without being biased by irrelevant information. Although it is desirable that experts can resist the biasing influence from contextual information and are better at doing so than novices, it has not yet been systematically investigated whether this is actually the case.

Present Study

The main question in the present study is whether experienced crime scene investigators behave differently compared to novices when investigating an ambiguous crime scene. In a previous study, we looked at the influence of prior information on the interpretation of the crime scene see (9). In the present study, we expand on our previous work and mainly focus on the search for and selection of forensic traces.

As we found no general measure or scale to define an expert (10,27) we defined experts in the present study as crime scene investigators who have experience in the field. In the Netherlands, experienced crime scene investigators are trained at the Dutch Police Academy. Knowledge on cognitive mechanisms and biases was not part of this training. Generally, experienced crime scene investigators have no or only limited knowledge of cognitive bias in forensic science. Novices were bachelor students in forensic science at a university of applied sciences that were at the end of their 4-year education. Those students could potentially become crime scene investigators, but are also trained in, for instance, laboratory work. The students had recently had their final theoretical courses on cognitive mechanisms and biases, but lacked practical experience in the field.

We expected that the novices would be less influenced by the contextual information compared to the experts when interpreting the crime scene as a whole, as they recently had training on cognitive biases. We expected that the novices would collect more traces compared to the experts as they explore the scene based on all objects present, whereas experts may explore the scene only based on objects with high evidential value. We furthermore expected that the experts would be better at searching for and finding crime-related traces compared to the novices, as their experience and skill to keep the bigger picture of the scene in mind may help them identify traces.

Method

Participants

The data of 58 experienced Dutch crime scene investigators and 36 fourth year students in applied forensic science were analyzed in the present study. Parts of the data originating from the crime scene investigators were previously described in (9), and the dataset of that study was compared with new data that was collected from the students in applied forensic science. The crime scene investigators were recruited among six of ten different police regions in the Netherlands, and their ages ranged from 27 to 63 years ($M = 44.8$, $SD = 8.9$). Their experience with the investigation of crime scenes ranged from 2 to 39 years ($M = 10.1$, $SD = 7.6$). Of the experienced crime scene investigators, 15 (26%) were female and 43 (74%) were male. The college students in applied forensic science participated as a part of a course in the final year of the 4-year applied forensic science program. They had not worked yet as crime scene investigators. Their ages ranged from 20 to 28 ($M = 22.37$, $SD = 2.13$). Of the students, 20 (56%) were female and 16 (44%) were male.

Design

The experiment consisted of a 2 (student vs expert) \times 3 (type of prior information) independent groups design. There were three different types of prior information. One group of participants received prior information that indicated that the victim committed suicide, another group received prior information that indicated that the victim was murdered, and the third group of participants received prior information without any indication on the cause of death, see also Appendix A for a more detailed description of the experimental design.

Materials

With help of forensic instructors of the Dutch Police Academy, a mock crime scene was constructed. In one of the crime houses that is used for training purposes for crime scene investigators, a female mannequin was hung in the stairwell. The crime scene was constructed to be ambiguous. There was evidence present for both suicide and murder, but in this case, we constructed a crime scene of a murder that the perpetrator staged as a suicide; see also (9). There were several crime-related traces present in the mock crime scene, such as blood on a fallen chair underneath the victim, blood on a door handle, and foreign hairs on the victim, which could help the participants with the interpretation of the scene (see Appendix B).

Participants in the suicide condition received information that the death was considered a supposed suicide due to a known history of depression. Participants in the murder

condition received information that the death was considered a supposed murder, due to previous accounts of domestic violence. Participants in the control condition only received information that the victim was found hanging and that there were no witnesses (see Appendix A for a detailed description of the contextual information).

The influence of prior information was measured at their initial assessment of the scene (first impression), during the investigation (traces they wanted to secure) and when participants were finished with the investigation (most likely scenario).

The ground floor of the crime house was recorded with a panoramic camera. The areas of the house that participants could investigate were the kitchen, the dining area, the living area, the staircase, and the hallway. The 360-degree images allowed participants to investigate the crime scene in a more dynamic way than with static pictures and allowed them to get a good overview of the scene. Detailed photographs of the crime scene were inserted into the panoramic scene, making it possible to detect small forensic traces. We wanted to encourage participants to actively reconstruct events at the scene and think about where crime-related traces could be found. Therefore, numerous detailed photographs with both crime-related and non crime-related items were inserted in the panoramic scene (9).

Procedure

The procedure that was followed was the same as described in (9). Corresponding with the instructions that were provided to the crime scene investigators in (9), students were first asked to read the case information that differed according to the condition. Then, they were provided with a set of four static photographs of the crime scene to get an overview of the situation. Subsequently, they wrote down a first impression of what had happened at the scene and rated confidence in that impression on a nine-point scale ranging from very uncertain to very certain. The static photographs were provided to the participants to enable them to get a general overview of the situation and to formulate a first impression before presenting them with detailed visual information about the crime scene.

Participants were all instructed on how to navigate through the panoramic photograph. After reading the instruction, participants were asked to sit in front of the computer and assess the ambiguous mock crime scene in the 360-degree panoramic photograph. They were told to reconstruct what had happened and to secure all crime-related traces. There was a 30-min time limit for the assessment of the virtual scene.

When the investigation was finished, participants were asked to write down which traces they wanted to secure and why. Every item or trace that they considered relevant could be written down, and there was no limit to the number of traces they could include. After carefully assessing the scene, participants again had to write down again what their impression of the crime scene was. If multiple answers were given, an additional question verified which of the options was most likely. Participants were also again asked to rate on a nine-point scale ranging from (1) very uncertain to (9) very certain how certain they were of their judgment of the most likely event. Lastly, some additional questions were asked addressing motivation, perceived time pressure, and confidence in finding the crime-related traces, also on a nine-point scale ranging from (1) very low to (9) very high.

Results

Preliminary Analyses

To assess whether there were other factors that could explain the differences between the experts and novices, we first performed some independent samples *t*-tests. Results indicated no significant effect of expertise on motivation to make a proper reconstruction of the event $t(90) = 1.61$, $p = 0.11$, perceived time pressure $t(92) = -0.01$, $p = 0.99$ or confidence in seeing the important traces $t(92) = -0.08$, $p = 0.94$.

First Impression of the Scene

The majority of both experienced crime scene investigators and students in all conditions wrote down suicide as the most likely scenario when we asked them to give their first impression after seeing the four photographs (see Fig. 1). In the student group, four participants in the murder condition and one in the neutral condition wrote down murder as a first impression. In the crime scene investigator group, only one participant in the murder condition wrote down murder as a first impression.

To gain more insight in the data, we created a new variable in which we combined context and expertise and included that variable in crosstabs with first impression. To test for overall significance, a chi-square test was performed ($\chi^2(10) = 27.58$, $p = 0.02$). Furthermore, the counts, row percentages, and adjusted residuals of all cells were displayed (see Table 1) to explore the data in more depth. The adjusted residuals indicate whether the counted numbers in each cell differ significantly from the expected numbers (28). In some cells, the counted and expected values did differ significantly. Students in the murder condition wrote down murder as a first impression significantly more than expected and suicide as a first impression less than expected. Crime scene investigators in the murder condition wrote down indecisive as a first impression significantly more than expected and suicide significantly less than expected.

Confidence in First Impression

A 2×3 ANOVA revealed a significant main effect of expertise on confidence in first impression ($N = 90$), $F(1, 84) = 6.47$, $p = 0.01$, $\eta^2 = 0.07$. The forensic science students were significantly more confident about their first impression ($M = 6.28$, $SD = 1.63$) compared to the crime scene investigators ($M = 5.49$, $SD = 1.45$). Furthermore, there was a significant main effect of context on confidence in first impression $F(2,$

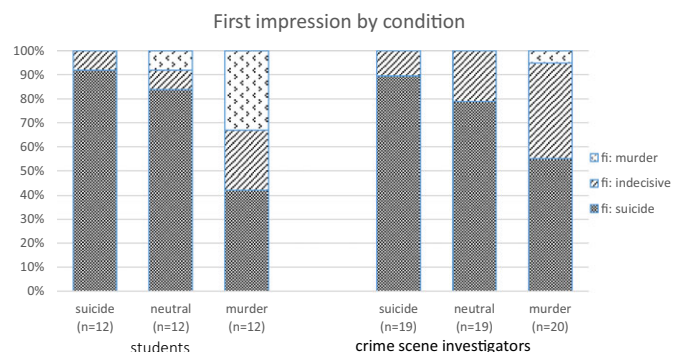


FIG. 1—First impression by condition. [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 1—Background \times condition \times first impression.

Condition	fi: Suicide	fi: Indecisive	fi: Murder
Student/Suicide			
Count	11	1	0
Row percentage	91.7%	8.3%	0.0%
Adjusted residual	1.5	-1.1	-1.0
Student/Control			
Count	10	1	1
Row percentage	83.3%	8.3%	8.3%
Adjusted Residual	0.8	-1.1	0.3
Student/Murder			
Count	5	3	4
Row percentage	41.7%	25%	33.3%
Adjusted Residual	-2.7*	0.4	4.1*
CSI/Suicide			
Count	17	2	0
Row percentage	89.5%	10.5%	0.0%
Adjusted Residual	1.8	-1.2	-1.3
CSI/Control			
Count	15	4	0
Row percentage	78.9%	21.1%	0.0%
Adjusted Residual	0.6	0.1	-1.3
CSI/Murder			
Count	11	8	1
Row percentage	55.0%	40.0%	5.0%
Adjusted Residual	-2.1*	2.5*	-0.3

* $p < 0.05$.

84) = 6.12, $p = 0.003$, $\eta^2 = 0.13$, with participants in the suicide condition being the most confident in their first impression ($M = 6.42$, $SD = 1.69$), then in the control condition ($M = 5.90$, $SD = 1.42$), and lastly in the murder condition ($M = 5.10$, $SD = 1.30$). A Tukey HSD post hoc analysis revealed that there was a significant difference between the murder and suicide condition on first impression ($p < 0.05$). There was no significant interaction between contextual information and expertise on confidence in first impression $F(2, 84) = 0.38$, $p = 0.68$.

Number of Secured Traces

A second 2×3 ANOVA showed a significant main effect of contextual information on the total number of secured traces ($N = 94$), $F(2, 88) = 4.94$, $p = 0.01$, $\eta^2 = 0.10$. Overall, participants in the murder condition secured the most traces on average ($M = 18.12$, $SD = 5.60$), then in the control condition ($M = 15.42$, $SD = 5.80$), and lastly in the suicide condition ($M = 13.65$, $SD = 4.62$). A Tukey HSD post hoc analysis revealed that there was a significant difference between the murder and suicide condition on number of secured traces ($p < 0.05$).

There was no significant main effect of expertise on the number of secured traces $F(1, 88) = 0.86$, $p = 0.36$ and no significant interaction between contextual information and expertise on the number of secured traces $F(2, 88) = 0.16$, $p = 0.86$.

Location of Traces

The virtual crime house was divided into different areas where participants could find traces. The areas were the hallway, the kitchen, the living room, and the area around the victim. Participants could write down anything they saw and wanted to secure; hence, there was no fixed maximum number of traces per area. Descriptive analyses showed that in general most traces were secured in the living room ($M = 7.65$, $SD = 2.78$), secondly around the victim ($M = 4.96$, $SD = 2.34$), thirdly in the kitchen

($M = 1.79$, $SD = 1.66$), and lastly in the hallway ($M = 0.93$, $SD = 1.41$). In the introduction of the study, we described that experts and novices may use different strategies when assessing a scene. We conducted independent samples t -tests to assess whether the number of secured traces in specific areas differed between students and crime scene investigators. The only significant difference was found for traces in the living room $t(92) = -2.82$, $p = 0.01$, where students ($M = 8.64$, $SD = 2.39$), secured significantly more traces compared to crime scene investigators ($M = 7.03$, $SD = 2.85$). There were no significant differences between students and crime scene investigators in the other areas (p values ranged from 0.15 to 0.43).

Crime-Related Traces

There were several crime-related traces in the mock crime scene that could help the investigators with the interpretation of the scene. Those were, for instance, blood on a fallen chair close to the victim and some hairs around the victim's neck that were longer and had a different color than the hair color of the victim.

Although it was previously shown that there was no significant difference between the students and the crime scene investigators with regard to the average number of traces they secured in general, there was a significant difference for the crime-related traces $t(92) = -2.26$, $p = 0.001$. Students secured more crime-related traces ($M = 12.56$, $SD = 2.78$), compared to the crime scene investigators ($M = 10.29$, $SD = 3.12$).

Furthermore, we assessed whether there were differences between the students and crime scene investigators as to which specific crime-related traces they secured. We found significant differences between students and experienced crime scene investigators for two crime-related traces, namely blood on the fallen chair $\chi^2(1) = 5.26$, $p = 0.02$, which was more often secured by the students (36.1%) compared to the crime scene investigators (15.5%), and the victim itself $\chi^2(1) = 7.99$, $p = 0.01$, which was also more often secured by the students (88.9%) compared to the crime scene investigators (62.1%).

Most Likely Scenario

After the crime scene was processed, participants gave an overall assessment of what might have happened. Figure 2 shows that participants in all conditions more often write down murder as a scenario, compared to the initial assessment of the scene.

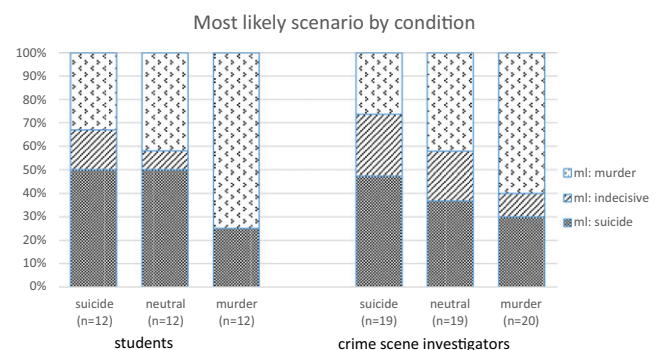


FIG. 2—Most likely scenario by condition. [Color figure can be viewed at wileyonlinelibrary.com]

We used the same procedure with the combined variables as described previously to run a chi-square test on context and expertise x most likely scenario. An overall chi-square test did not show a significant association between context, expertise, and most likely scenario ($\chi^2(10) = 11.04, p = 0.36$).

Confidence in Most Likely Scenario

A 2×3 ANOVA revealed no significant main effect of expertise on confidence in most likely scenario ($N = 88$), $F(1, 82) = 0.78, p = 0.38$. No significant main effect of contextual information on confidence in most likely scenario $F(2, 82) = 0.44, p = 0.64$, and no significant interaction between contextual information and expertise on confidence in most likely scenario $F(2, 82) = 0.99, p = 0.38$.

Discussion

The aim of the present study was to assess whether students or experienced crime scene investigators were more vulnerable to the influence of contextual information.

The findings of our study demonstrate that context information has an impact on the behavior at the crime scene, regardless of experience. This study shows that contextual information not only impacts work in forensic laboratories, such as interpreting fingerprints and DNA analysis results (e.g., [5,29]), but also crime scene investigators working at the crime scene. Our study shows that regardless of experience, context impacted the number of traces secured, with participants in the murder condition securing the most traces on average. However, we found no differences in the total number of secured traces between the students and crime scene investigators. Perhaps, even though novices explore crime scenes more in terms of objects, similar objects were of interest to both groups in their crime scenarios, as previous research also indicated that both experts and novices reconstruct events by the *modus operandi* of the criminal to make sense of the scene (26).

Our study further indicates that students secure more crime-related traces compared to experienced crime scene investigators. Also, the students more often secured two important crime-related traces, namely the blood on the fallen chair and the victim itself that could help to arrive at the right conclusion. This is contrary to our expectations and the finding of Baber and Butler (26) that experts are better at finding crime-related evidence. Maybe it does help to also explore the scene in terms of all individual objects, instead of mainly based on objects that are likely to contain usable trace evidence and consequently could be used in court, to increase the chance of finding crime-related traces. Furthermore, students secured significantly more traces in the living room. This finding may be in line with the finding by Baber and Butler (26) who found that novices were more focused on objects in a scene. In our crime scene, there were many objects in the living room that could draw the attention even without having a clear crime scenario.

We also examined whether there was a difference between experts and novices in how they interpreted the crime scene. Results showed that there were some differences between the groups with regard to the interpretation of the crime scene at the start of the investigation. Students in the murder condition wrote down murder as a first impression significantly more than expected and suicide as a first impression less than expected. Crime scene investigators in the murder condition wrote down indecisive as a first impression significantly more than expected

and suicide significantly less than expected. In all conditions, the majority of the participants wrote down suicide as a first impression. Furthermore, participants in the suicide condition showed most confidence in their first impression. This confidence may be explained by the fact that the scene looked quite neat and clean, but is also possible that all participants considered base-rate information about unnatural deaths. The vast majority of unnatural deaths in the Netherlands are suicide cases, and the annual number of suicides is ten times higher than the number of murders (30). That knowledge of base rates may make it difficult to compare the groups and isolate the influence of contextual information, especially on first impression without detailed information of the crime scene itself. The students were more confident about their first impression compared to the crime scene investigators. This is in contrast with the literature in which it is stated that experts can be (overly) confident in their judgments (21).

After the investigation was finished, participants were asked to write down the most likely scenario. Results indicated no differences between the conditions. Although there were no differences between the conditions, results also showed that participants in all conditions more often wrote down murder as a scenario, compared to the initial assessment of the scene. Hence, for both experts and students, processing the scene leads to a different interpretation of the crime scene. This finding is somewhat contradictory to research findings on belief perseverance, which state that people have the tendency to maintain a belief despite opposing evidence (31). However, our finding that even though participants already constructed an hypothesis of what might have happened before they assessed the scene and were still able to incorporate new information and adjust that hypothesis after collecting evidence may indicate that crime scene investigators are mentally flexible enough to keep an open mind to opposing evidence and the accumulation of evidence when assessing the crime scene.

In our introduction, we stated that we expected that the novices would be less influenced by the contextual information compared to the experts when interpreting the crime scene as a whole, as they recently had training on cognitive biases. The findings do not support this hypothesis. It is important to note that to date there is no empirical evidence what an effective training on cognitive bias constitutes. Furthermore, it is important to note that awareness of bias is not necessarily a protective factor against it and that forensic experts consider bias as something that mainly concerns others, not themselves (8,32). Lastly, training on cognitive bias should include solutions. Although several solutions have been proposed for forensic investigations in the laboratory (33), these methods are difficult, if not impossible, to implement at the investigation of a crime scene. Therefore, it is vital to conduct further research in this field.

There are several potential limitations of the present study that are similar to the ones described in (9). Firstly, the study relied on a mock crime scene that was presented in a virtual environment. Several participants, mostly crime scene investigators, indicated that they missed the "feel" of an actual crime scene. Although virtual crime scenes have also been used in other studies to assess crime scene behavior (34), there is to our knowledge no empirical evidence that shows that behavior in a virtual crime scene generalizes well to that in a real crime scene. However, there is to date also no evidence for the contrary, namely that behavior in virtual scenes does not generalize well to that in a real crime scene. This is something that could be addressed in the future studies. Secondly, a female mannequin was used, so it was not possible for the participants to include information that can be derived from the victim's body in their assessment of the

scene. Thirdly, only one crime scene was used to test the possible influence of prior information. Findings from the present study can therefore not be generalized to all crime scenes and all criminal cases.

Students may be more skilled in using a computer compared to the crime scene investigators, and this may have worked in the students' favor when assessing the scene. A further limitation of the present study could include the small sample size of 58 crime scene investigators and 36 students, which may limit statistical power. Although we are aware that the student sample especially is quite small, it was a specific sample of a class that was at the end of a 4-year education, making it difficult to recruit more students at the time. Also, the computer system we used to present the participants with the virtual crime scene is no longer available. Consequently, it is no longer possible to present the virtual crime scene to a new group of students in exactly the same manner. Therefore, conducting similar studies in the future is important to test the robustness of the findings of the present study.

Although the absence of effects we predicted may be explained by limited statistical power a different take on these null findings is that potentially the training in cognitive bias students received has brought the students up to the same level as the experts, despite the extensive field experience of the latter group. In other words, the training methods used could be effective in helping novices show resistance to potentially confounding contextual details when assessing a crime scene. However, this is something that should be further investigated in the future studies. Preferably with a student sample which has a similar academic level as the crime scene investigators.

A final limitation namely concerns the difference in academic level between the students and the crime scene investigators. The students have a somewhat higher academic level and different educational background compared to the crime scene investigators. Hence, this difference may be large enough to confound the findings in the present study. It is therefore important to replicate the present study with novice crime scene investigators who are in the same educational program as the experienced crime scene investigators followed.

Conclusion

Even though the present study was one of the first to investigate the role of expertise in crime scene investigation and there are limitations to take into account, it is important to note that some of the findings go against general beliefs. Detectives believe that professional experience and proper training are the most important protection against factors that may detrimentally influence investigations (35). The present study provides no evidence that professional experts outperform novices. Hence, the findings in the present study argue for proper training on cognitive processes and biases as an integral part of the education of every crime scene investigator as well as every forensic science student.

Acknowledgments

The authors gratefully acknowledge the crime scene investigators and students who participated in this study.

References

- Kassin SM, Dror IE, Kukucka J. The forensic confirmation bias: problems, perspectives, and proposed solutions. *J Appl Res Mem Cogn* 2013;2:42–52.
- National Research Council. Strengthening forensic science in the United States: a path forward. Washington, D.C.: The National Academies Press, 2009.
- Institutes ENoFS. ENFSI guideline for evaluative reporting in forensic science. Strengthening the evaluation of forensic results across Europe (STEOFRAE). The Hague, Netherlands: European Network of Forensic Sciences Institutes, 2015.
- Regulator FS. Cognitive bias effects relevant to forensic science examinations. London, U.K.: Home Office, 2015.
- Dror IE, Hampikian G. Subjectivity and bias in forensic DNA mixture interpretation. *Sci Justice* 2011;51(4):204–8.
- Fraser-Mackenzie PAF, Dror IE, Wertheim K. Cognitive and contextual influences in determination of latent fingerprint suitability for identification judgments. *Sci Justice* 2013;53(2):144–53.
- Nakhaeizadeh S, Dror IE, Morgan RM. Cognitive bias in forensic anthropology: visual assessment of skeletal remains is susceptible to confirmation bias. *Sci Justice* 2014;54(3):208–14.
- Kukucka J, Kassin SM, Zapf PA, Dror IE. Cognitive bias and blindness: a global survey of forensic science examiners. *J Appl Res Mem Cogn* 2017;6(4):452–9.
- Van den Eeden CAJ, De Poot CJ, Van Koppen PJ. Forensic expectations: investigating a crime scene with prior information. *Sci Justice* 2016;56(6):475–81.
- Ericsson KA. An introduction to Cambridge handbook of expertise and expert performance: Its development, organization and content. In: Ericsson KA, Charness N, Feltovich P, Hoffman R, editors. *The Cambridge handbook of expertise and expert performance*. New York, NY: Cambridge University Press, 2006;3–21.
- Chi MTH. Two approaches to the study of experts' characteristics. In: Ericsson KA, Charness N, Feltovich P, Hoffman A, editors. *The Cambridge handbook of expertise and expert performance*. New York, NY: Cambridge University Press, 2006;21–30.
- De Groot A. Thought and choice in chess. Den Haag, Netherlands: Mouton, 1965.
- Lesgold A, Rubinson H, Feltovich P, Glaser R, Klopfer D, Wang Y. Expertise in a complex skill: diagnosing x-ray pictures. In: Chi MTH, Glaser R, Farr MJ, editors. *The nature of expertise*. Hillsdale, NJ: Lawrence Erlbaum Associates Inc, 1988;311–42.
- Santtila P, Korpela S, Hakkanen H. Expertise and decision-making in the linking of car crime series. *Psychol Crime Law* 2004;10(2):97–112.
- Lemaire P, Siegler RS. Four aspects of strategic change: contributions to children's learning of multiplication. *J Exp Psychol Gen* 1995;124(1):83–97.
- Alexander PA. Can we get there from here? *Educ Res* 2003;32(8):3–4.
- Tuckey M, Brewer N. How schemas affect eyewitness memory over repeated retrieval attempts. *Appl Cogn Psychol* 2003;17(7):785–800.
- De Poot CJ, Bokhorst RJ, Van Koppen PJ, Muller ER. Rechercheportret: over dilemma's in de opsporing [Portrait of detectives: about dilemmas in the criminal investigation]. Alphen aan de Rijn, Netherlands: Kluwer, 2004.
- Christensen C, Heckerling PS, Mackesy ME, Bernstein LM, Elstein AS. Framing bias among expert and novice physicians. *Acad Med* 1991;66(9 Suppl):S76–8.
- Dror IE. The paradox of human expertise: why experts can get it wrong. In: Kapur N, Pascual-Leone A, Ramachandran VS, editors. *The paradoxical brain*. New York, NY: Cambridge University Press, 2011;177–88.
- Chi MTH. Knowledge structure and memory development. In: Siegler RS, editor. *Children's thinking: what develops?*. Hillsdale, NJ: Erlbaum, 1978;73–96.
- Adelson B. When novices surpass experts: the difficulty of a task may increase with expertise. *J Exp Psychol Learn Mem Cogn* 1984;10(3):483–95.
- Baber C. Distributed cognition at the crime scene. *AI & Soc* 2010;25(4):423–32.
- Klein G. The Recognition-Primed Decision (RPD) model: looking back, looking forward. In: Zsombok CE, Klein GA, editors. *Naturalistic decision making*. Mahwah, NJ: Lawrence Erlbaum Associates, 1997;285–92.
- Schraagen JM, Leijtenhorst H. Searching for evidence: knowledge and search strategies used by forensic scientists. In: Salas E, Klein G, editors. *Linking expertise and naturalistic decision making*. Mahwah, NJ: Lawrence Erlbaum, 2001;263–74.
- Baber C, Butler M. Expertise in crime scene examination: comparing search strategies of expert and novice crime scene examiners in simulated crime scenes. *Hum Factors* 2012;54(3):413–24.
- Dror IE. A hierarchy of expert performance. *J Appl Res Mem Cogn* 2016;5(2):121–7.
- Haberman SJ. The analysis of residuals in cross-classified tables. *Biometrics* 1973;29(1):205–20.

29. Dror IE, Peron AE, Hind SL, Charlton D. When emotions get the better of us: the effect of contextual top-down processing on matching fingerprints. *Appl Cogn Psychol* 2005;19(6):799–809.
30. Statistiek CBvd, 2016; http://statline.cbs.nl/StatWeb/publication/?DM=SLNL&PA=7052_95&D1=a&D2=a&D3=0&D4=0,41,51,1&HDR=G2,G1,G3&STB=T&VW=T (available December 21, 2017).
31. Koehler DJ. Explanation, imagination, and confidence in judgment. *Psychol Bull* 1991;110(3):499–519.
32. Van den Eeden CAJ, De Poot CJ, Van Koppen PJ. From emergency call to crime scene: information transference in the criminal investigation. *Forensic Sci Policy Manage* 2017;8(3–4):79–89.
33. Dror IE. Practical solutions to cognitive and human factor challenges in forensic science. *Forensic Sci Policy Manage* 2013;4(3–4):1–9.
34. De Gruijter M, Nee C, De Poot CJ. Identification at the crime scene: the sooner, the better? Constructing scenarios with rapid identification information at the crime scene. *Sci Justice* 2017;57(4):296–306.
35. Fahsing I, Ask K. Decision making and decisional tipping points in homicide investigations: an interview study of British and Norwegian detectives. *J Invest Psychol Offender Profiling* 2013;10(2):155–65.

Appendix A

Context Information

Murder Condition

On 25-04-2013, about 15.05 pm, a message was received of a hanging in a house at Haagweg 2 in Apeldoorn. Ambulance staff concluded that the victim had died. A neighbor who passed by every day to keep an eye on things found the victim. There is a suspicion that the death is a potential crime, because of the situation encountered and the fact that previous reports of domestic violence have been received from this address. A witness who worked in the park in the street all day has stated that at the end of the morning, he saw a man leaves the house.

Suicide Condition

On 25-04-2013, about 15.05 pm, a message was received of a hanging in a house at Haagweg 2 in Apeldoorn. Ambulance staff concluded that the victim had died. A neighbor who passed by

every day to keep an eye on things found the victim. There is a suspicion that the death is a suicide, because of the situation encountered and the fact that the victim was known to the general practitioner because of depressive symptoms. A witness who worked in the park in the street all day has stated that he had not noticed anything particular all day and did not see anyone leaving the house.

Neutral Condition

On 25-04-2013, about 15.05 pm, a message was received of a hanging in a house at Haagweg 2 in Apeldoorn. Ambulance staff concluded that the victim had died. The victim was found by a neighbor. There were no witnesses in the vicinity of the house.

Appendix B

Crime-Related Evidence in the Mock Crime Scene

Rope
Knot
Victim
Hairs on victim
Robe
Blood on chair
Blood on door handle
Gravel from flower pot
Fallen candle holder
Suicide note
Medication
Pen
Glass
Diary
Coffee cups
Cigarettes
Shopping list